

Mercury in Drilling Muds

Presented by

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Minerals Management Service



Overview

- What is Mercury?
- Mercury in the Environment
- Mercury in an Industrialized Society
- Mercury in Drilling Fluids
- Minerals Management Service Studies



What is Mercury?

- A naturally occurring element
- Symbol is Hg, hydrargyrum - “watery silver”
- Commonly known as Quicksilver
- Not a nutrient, like some metals (zinc)

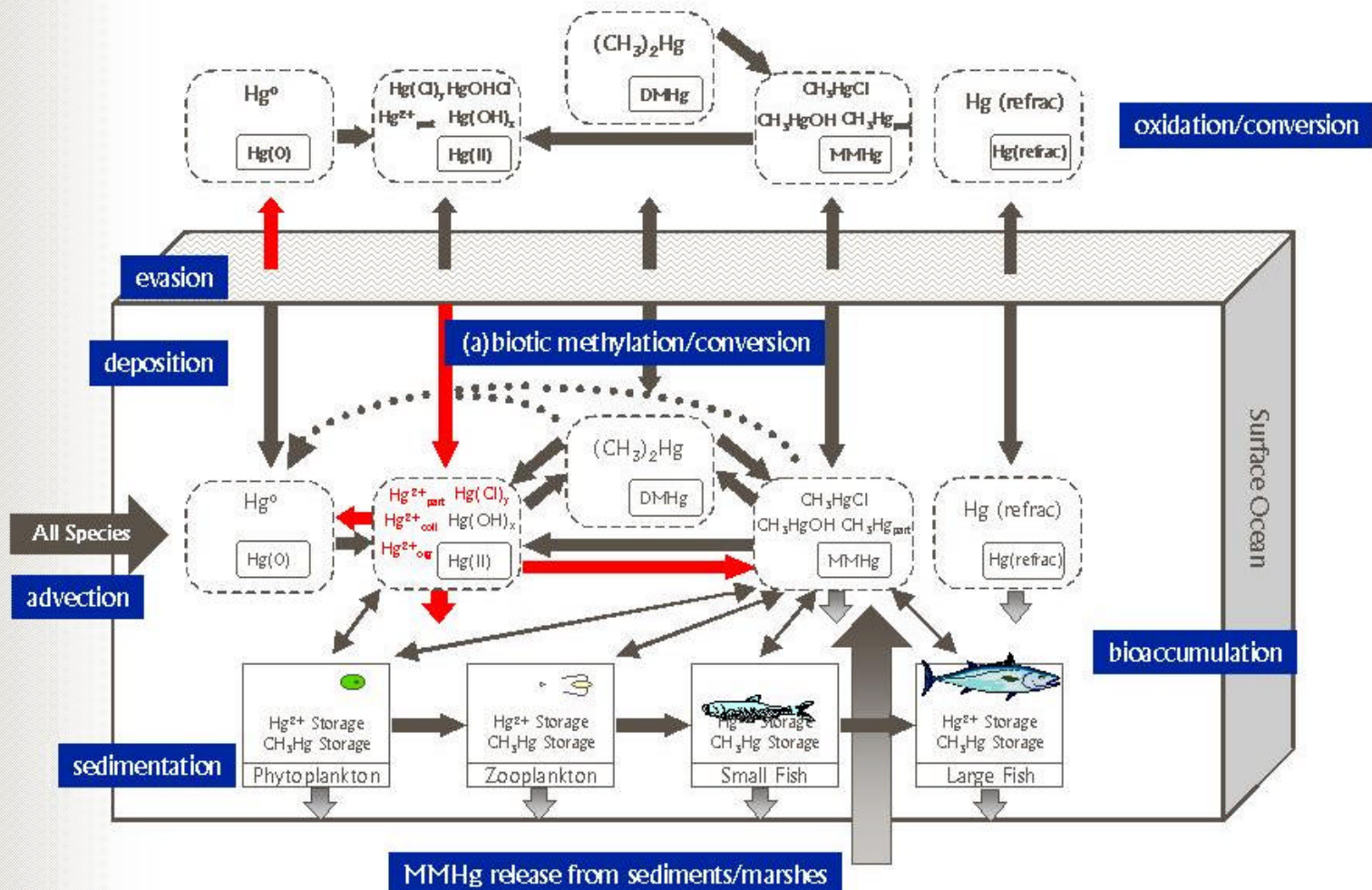


Mercury in the Environment

- Elemental Mercury - liquid or gas - Hg^0
 - Silvery liquid in a thermometer
 - Gas in the atmosphere
- Inorganic mercury - salt or mineral - Hg^{2+}
 - Dissolved in water
 - Mineral Cinnabar - HgS
- Organic mercury - methylmercury - CH_3Hg^+



Mercury Biogeochemistry





Mercury to Methylmercury

- Natural process
- Converted to methylmercury by bacteria
- Only a few types (species) of bacteria
- Can occur without bacteria but rarely
- Possibly occurs in some plants



Mercury

- Bioavailable
 - In a chemical form that can affect organisms
- Bioaccumulation
 - What goes in is greater than what goes out
- Biomagnification
 - Transfer up the food chain

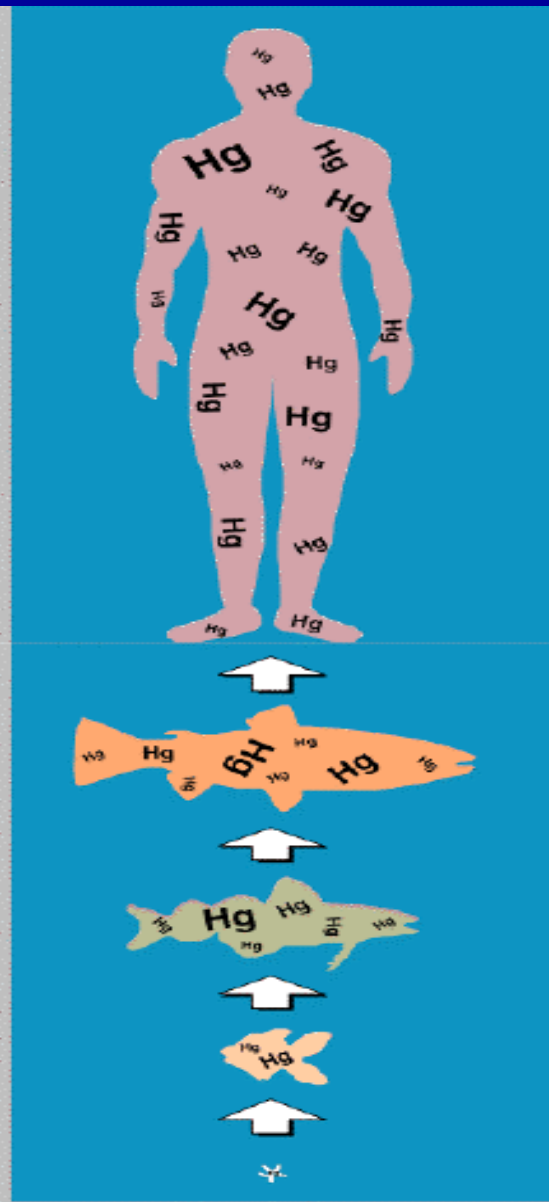
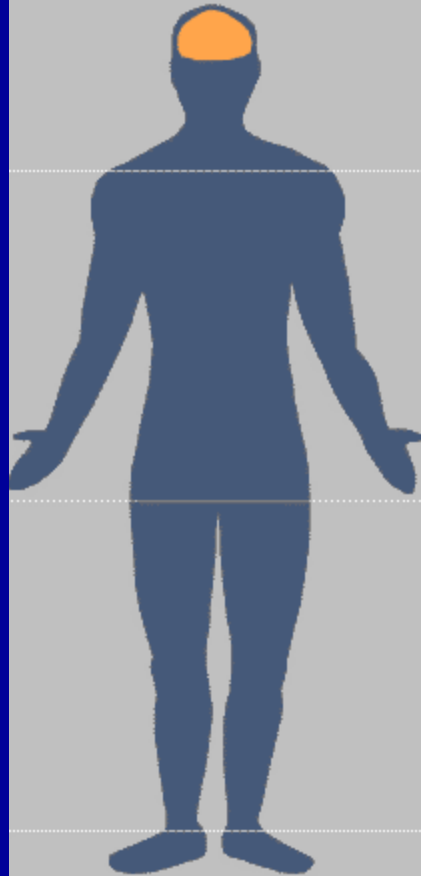


Figure 4. Mercury (Hg) biomagnifies from the bottom to the top of the food chain. Even at very low input rates to aquatic ecosystems that are remote from point sources, biomagnification...

MERCURY HEALTH EFFECTS



- ❑ Deteriorates nervous system
- ❑ Impairs hearing, speech, vision and gait
- ❑ Causes involuntary muscle movements
- ❑ Corrodes skin and mucous membranes
- ❑ Causes chewing and swallowing to become difficult

Figure 5. All forms of mercury are toxic to humans, but methylmercury is especially of concern because our bodies have a less well developed defense mechanism against this toxin. Effects on the nervous system are the most prevalent in humans.

Mercury Poisonings

- Minimata, Japan - 1950's
 - Industrial Plant Discharge
 - Mercury in seafood consumed by local population
- Iraq 1961
 - Seeds coated with fungicide - phenylmercury
 - Seeds were used to make bread



Mercury in an Industrialized Society

- Pre-industrial - Mirrors and felt
 - “Mad as a Hatter”
- Chlor-alkali plants (Lavaca Bay)
- Paper plants, agriculture
- Latex paints
- Dental amalgam
- Household products

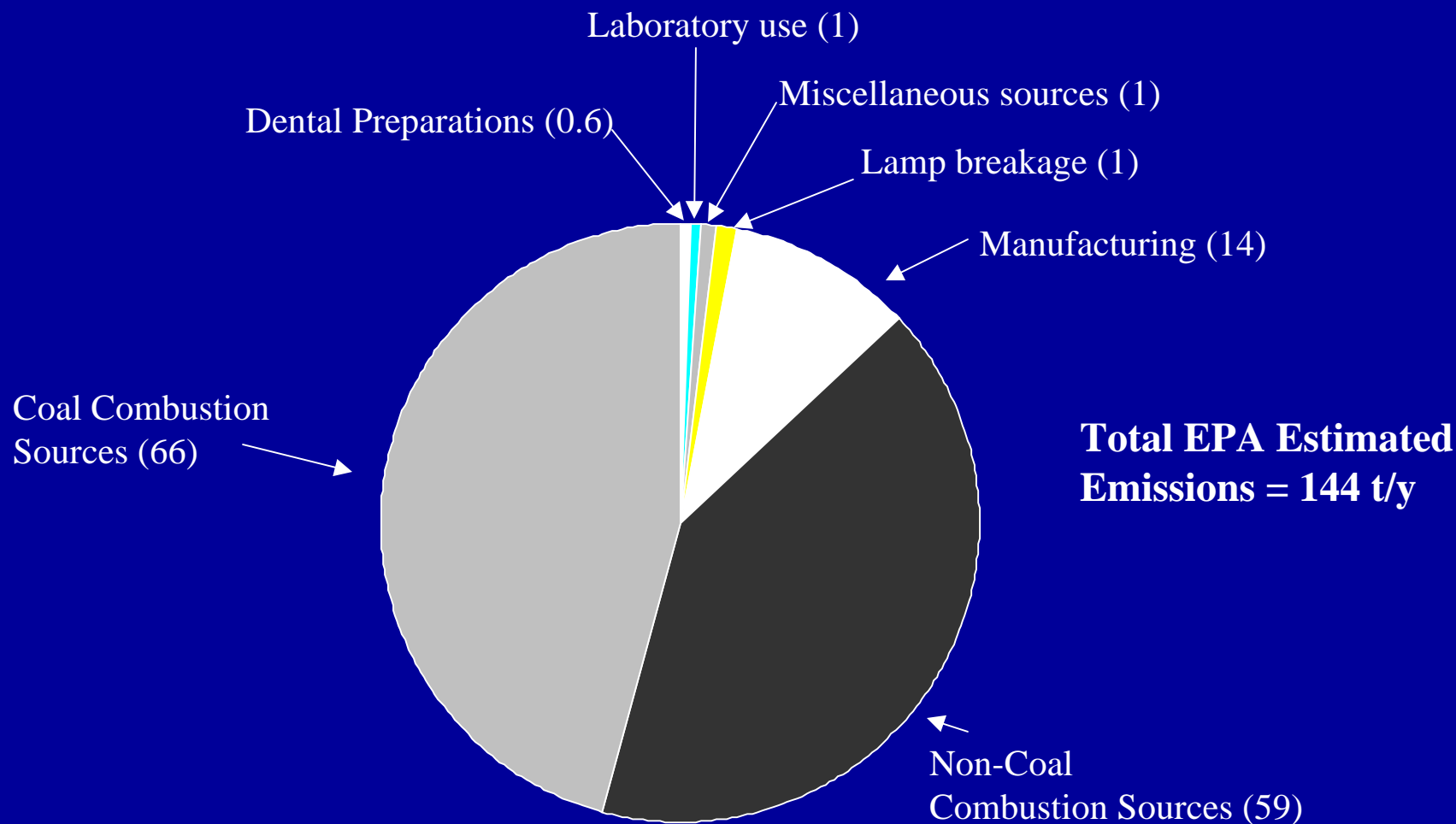




Atmospheric Mercury Sources

- Municipal and solid waste incinerators
- Medical waste incinerators
- Coal-fired power plants

US Mercury Emissions '94-95 (metric t/y)



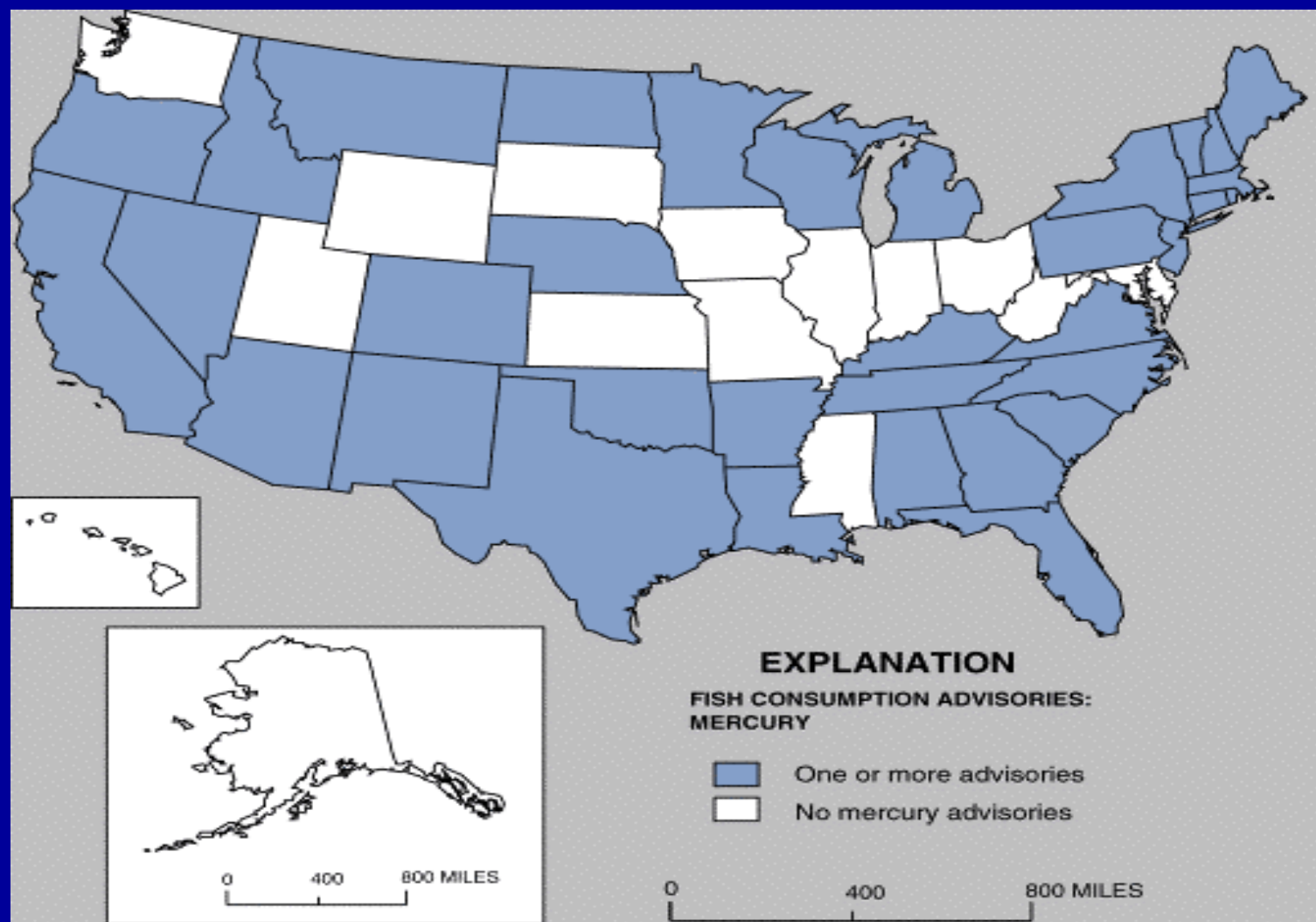


Figure 1. States with at least one fish consumption advisory for mercury. Source: USEPA Fish Consumption Data Base



Mercury in Drilling Fluids

- Present in Barite as trace contaminant
- Barite used as weighting agent
- Barite composes 40% of fluid on average
- Mercury concentrations less than 1 ppm
 - Regulated by EPA through NPDES permit





Mercury: Barite \Rightarrow Fish

- Step 1: Mercury must be released from barite
- Step 2: Mercury must be in form that is bioavailable
- Step 3: Bacteria that methylate must be present
- Step 4: Mercury must cross cell wall
- Step 5: Mercury must be methylated
- Step 6: Methylmercury must be bioavailable
- Step 7: Methylmercury is incorporated into food chain
- Step 8: Mercury is biomagnified up food chain to fish

Minerals Management Service Studies

- Atlantic and California
 - mercury included as part of general surveys
- Alaska - A workshop and two studies
 - Related to gold mining off the Alaska coast
- No direct mercury studies in GOMR
 - Not a part of the industrial process
 - Discharges studied/regulated by EPA
 - Included as “suite” of trace metals

Minerals Management Service Studies

- Several completed studies where mercury was part of suite of metals analyzed:
 - Mississippi Alabama Marine Ecosystem Study - 1991
 - Gulf of Mexico Offshore Operations Monitoring Experiment - 1995
 - An Observational Study of the Mississippi-Atchafalaya Coastal Plume - 1998

Minerals Management Service Studies

- Several ongoing studies where mercury is included:
 - Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study
 - Joint Industry Project: Gulf of Mexico Comprehensive Synthetic Based Muds Monitoring Program
 - Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico

Other Information Sources

- Environmental Protection Agency
 - Development documents for NPDES permits
- Industry sponsored research

Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX)

- Goals
 - Identify chronic, sublethal effects of offshore oil and gas production activities on marine organisms
 - Relate effects to a contamination gradient around platforms
 - Recommend monitoring strategies

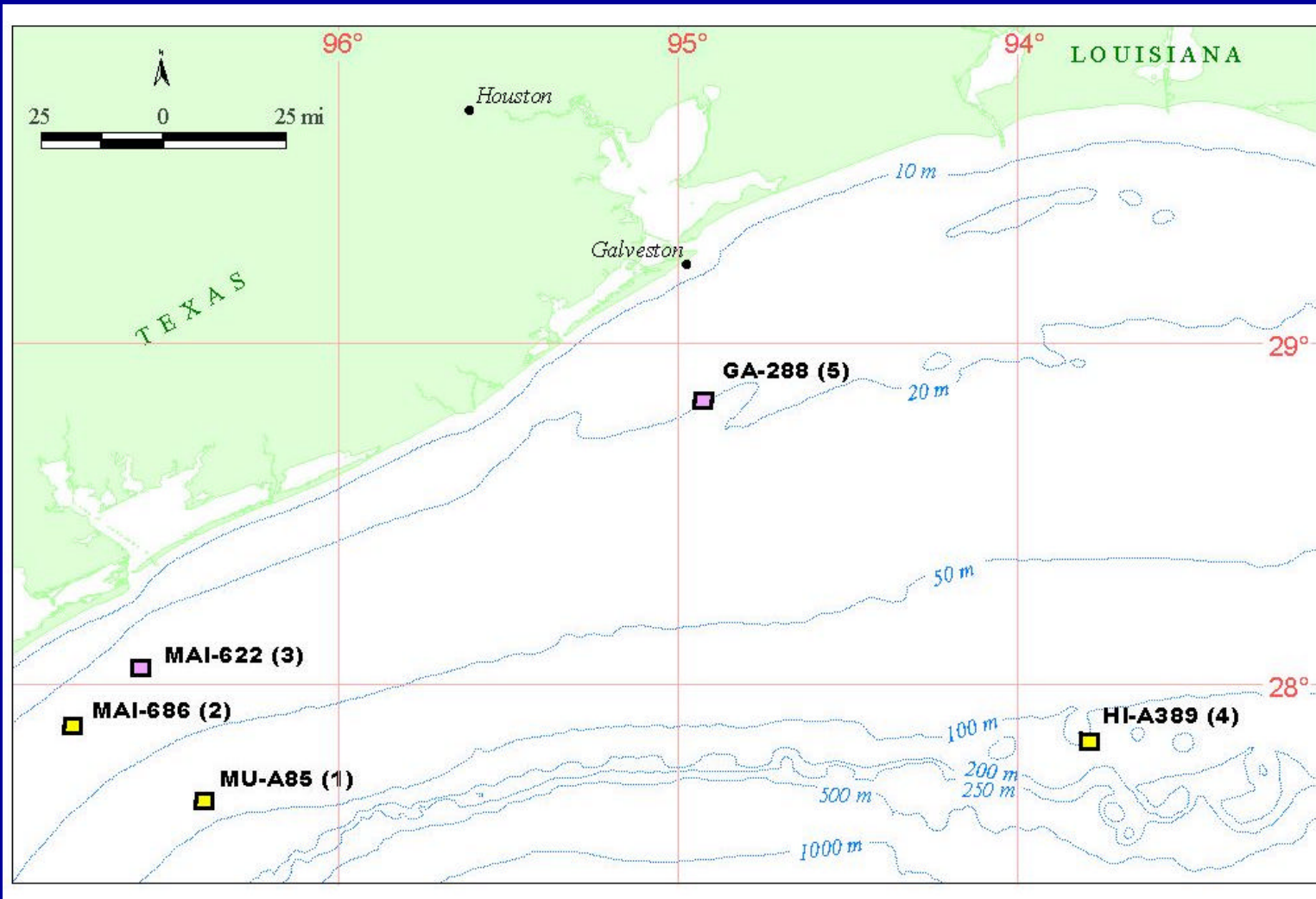
Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX)

- 5 platforms surveyed, 3 studied in detail
- 5 distances from the platform
 - 50, 100, 200, 500, 3000 meters
- 5 replicate radii
- 4 sampling periods
 - 2 years x 2 seasons (winter and summer)

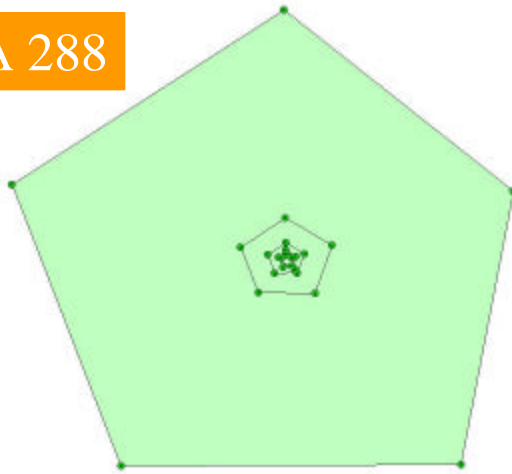
Total Mercury in the Sediment

Total Hg (ppm, dry wt)	Biological Effects	Color
< 0.15	Rarely	Green
0.15 - 0.71	Occasionally	Yellow
> 0.71	Frequently	Red

Sampling Locations from GOOMEX

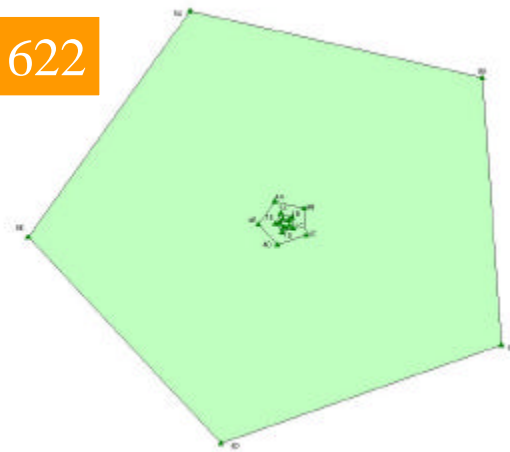


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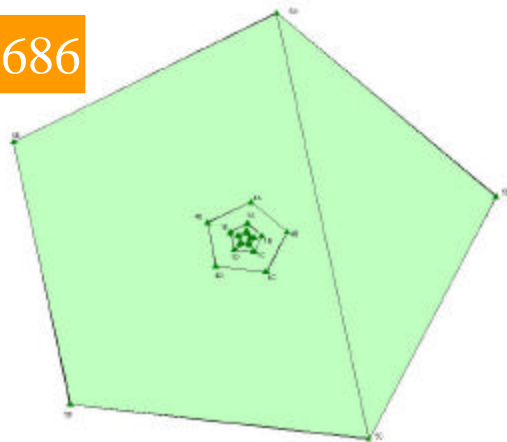


Total Mercury in Sediments

MAI 622

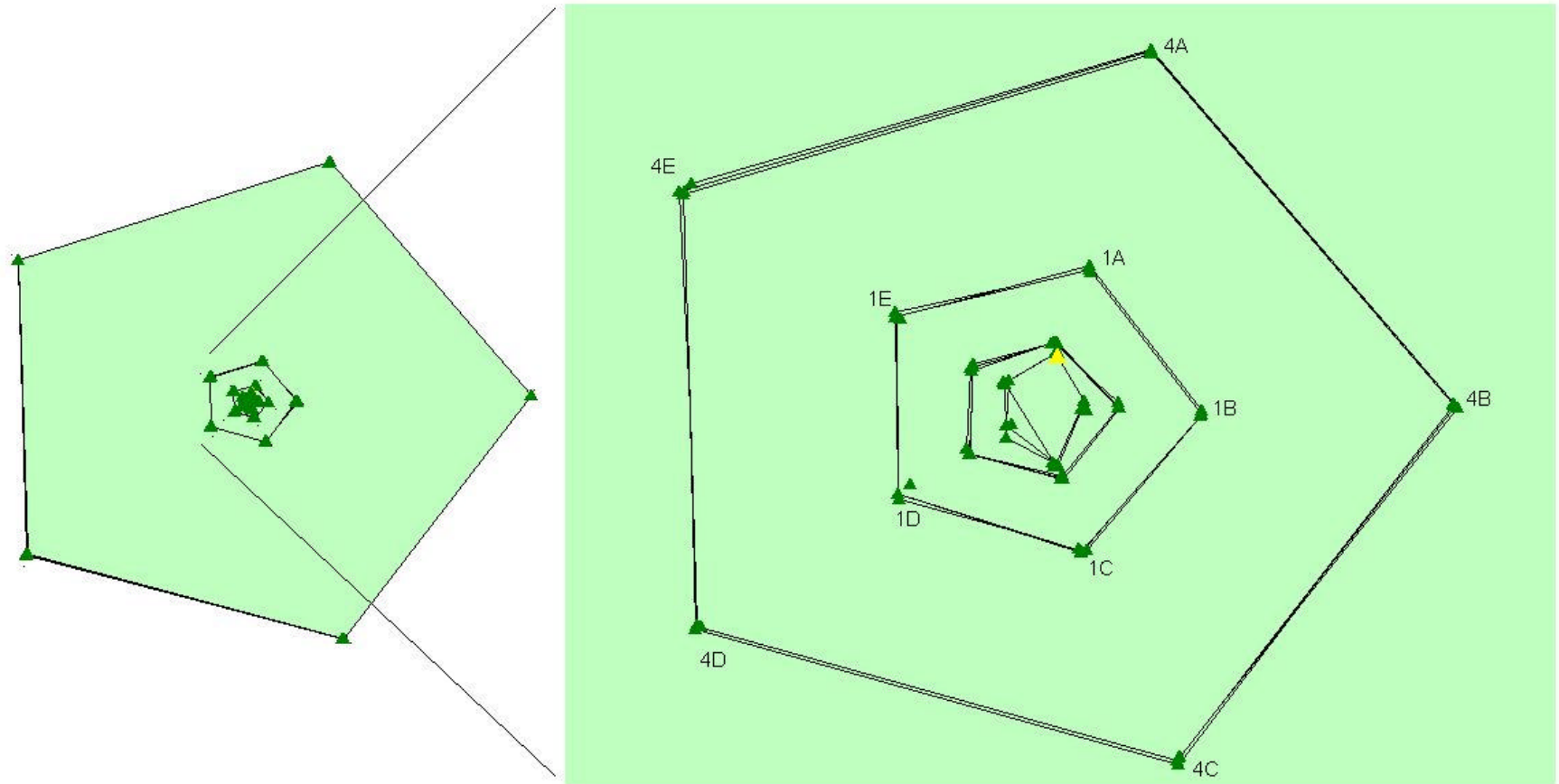


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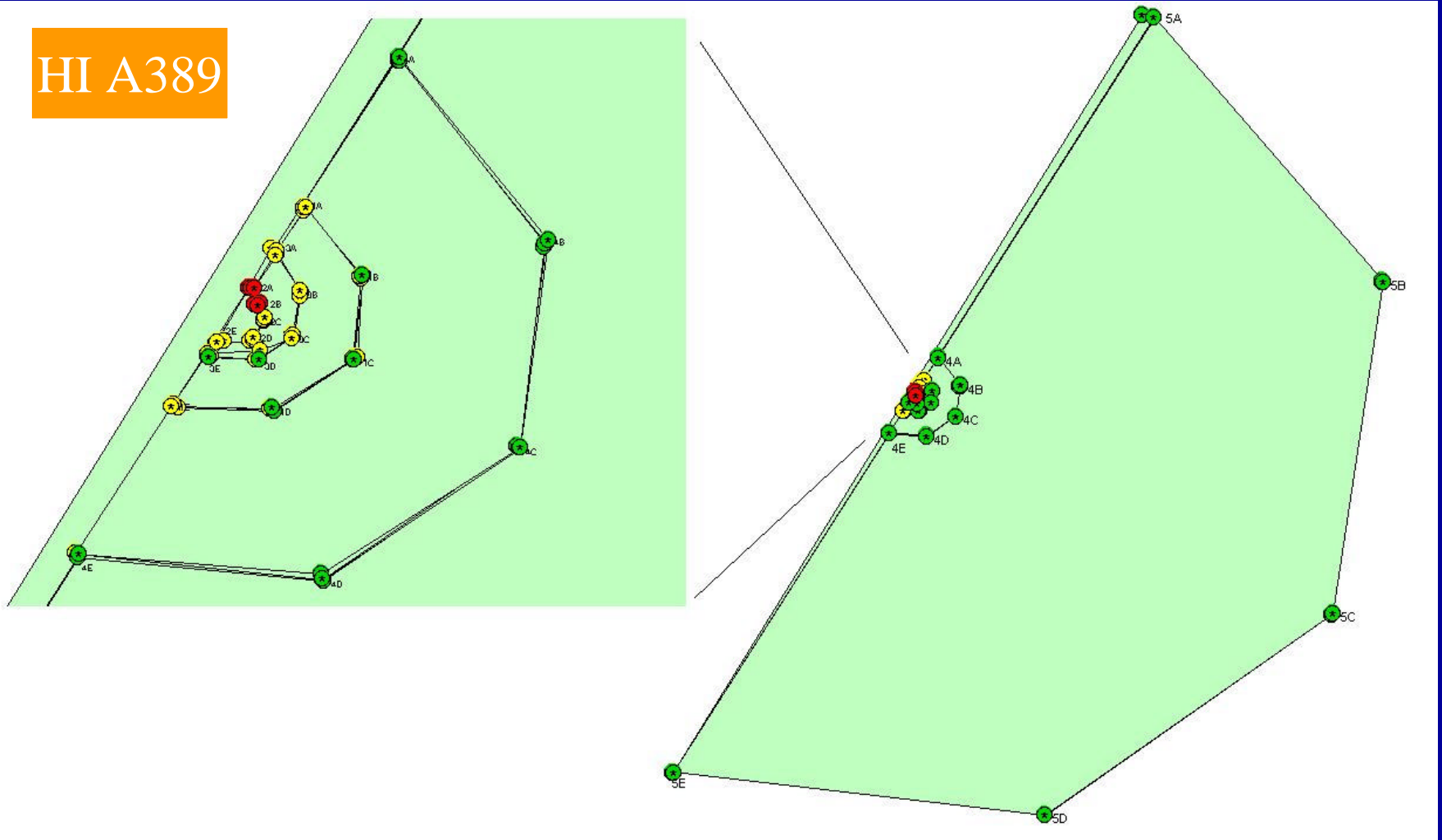
Total Mercury in Sediments

MU A85



Total Mercury in Sediments

HI A389



HI-A389

- Total mercury at two locations ranged from 1.0 to 3.5 parts per million
- Mercury is from drilling mud
- Drilling occurred between 1975 and 1983
- Drilling mud/cuttings shunted to within 10 meters of the bottom

Total Mercury in Tissues

- Identify chronic, sublethal effects of offshore oil and gas production activities on marine organisms
- Samples collected near (< 100 m) and far (> 3000 m) using nets
- Analyzed invertebrate (shrimp, crabs), fish liver samples, and fish stomach contents

Total Mercury in Tissues

- Results indicated that there was no statistical difference between near and far samples
- Concluded that platforms do not support enhancement of mercury in marine organisms

Information about Mercury

- WHO 1990 report on Methylmercury
- EPA's 1997 report to Congress
- Toxicological Profile for Mercury - 1999
Agency for Toxic Substances and Disease
Registry (ATSDR)
- NAS' 2000 report on Methylmercury
- Proceedings from International Mercury
Conferences (6 since 1990)
- Thousands of scientific articles